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TAXONOMIC CHARACTERS, VARIABILITY, AND RELATIVE GROWTH IN *CIMEX LECTULARIUS* L. AND *C. COLUMBARIUS* JENYNS (HETEROPT. CIMICIDAE)

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(*Department of Entomology, London School of Hygiene and Tropical Medicine.*)

Communicated by Dr. O. W. Richards, F.R.E.S.

With Plate 1, Eight Figures, and Thirteen Tables.

(Read 1st March, 1939.)

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I. Introduction.

Cimex columbarius, the pigeon-bug, was described as a new species by Jenyns in 1839; it is, however, so similar to the bed-bug, *C. lectularius* L., in its general appearance that its status as a species has been questioned (Kassianoff, 1936; Slack, 1937; Hase, 1938) and identification has been a matter of difficulty. I therefore studied certain morphological features primarily in order to find a character distinguishing these two insects.

Jenyns (1839) compared *lectularius* and *columbarius* and wrote that *columbarius* is " smaller and of a more orbicular form " and that :—

> the " *antennae* are shorter and the joints not quite so slender; and the difference in length between the third and fourth joints not so considerable. The *thorax* is rather less hollowed out in front, the anterior angles less

produced, and the sides less reflexed. The *abdomen* more nearly approaches to round, the lateral margins being very much curved, and the greatest breadth exactly in the middle; whereas in the house-bug the lateral margins are at first but little curved, and the greatest breadth rather behind the middle. The *colours* as well as the punctures and the degree of pubescence, are similar in the two species."

In view of the extreme similarity in the general facies of the two insects (pl. 1.) the existence of distinguishing morphological differences would most likely be in a relative proportion of parts. Certain ratios were therefore studied. Linear measurements were deemed preferable to those involving curves (such as in the shape of the flange and the anterior angles of the pronotum) and although the shape of the abdomen often seems distinctive when *lectularius* and *columbarius* are compared side by side, this possible distinction was not studied owing to difficulties in standardising the large variation in abdominal distension.

From Jenyns' original description it seemed that the difference in relative length of the 3rd to 4th antennal segments might be a distinctive character; other workers too (Saunders, 1892; Horvath, 1910; Wibaut-Isebree Moens, 1925; Slack, 1937) have used this feature to distinguish *columbarius* from *lectularius*. I have, however, found it to be very unreliable for this purpose. Ratios of other parts were then considered and one has been selected (head-width/length of 3rd antennal segment) with which it is possible to distinguish populations, and with less certainty individuals, of *lectularius* and *columbarius* reasonably well. Every ratio of possible systematic importance has not been investigated; others undoubtedly exist and among them may be one taxonomically more reliable than the head-width/3rd antennal segment. From the nature of relative growth of different parts of an insect, however, it is almost certain that the use of other ratios would present difficulties similar to those experienced in the present study.

From the primary search for a good character this work has expanded into a study of the local variation of the value for 3rd/4th antennal segments and head-width/3rd antennal segment in *lectularius* and *columbarius*. Bug populations possessing mean values of these ratios intermediate between those for *lectularius* and *columbarius* must obviously at present be regarded as intermediate in no more than these (and perhaps also head-width/total length of antenna) two characters.

The material with which these investigations deal had been identified when I received it. This could have been done for *columbarius* either on the basis of Jenyns' description or simply because the insects had been found with pigeons. The fact that the majority of the *lectularius* were found with man as well as their general morphological characters possibly swayed the identifiers in their decisions.

When the ratio, length of 3rd/length of 4th antennal segment, was found to be unreliable for distinguishing *columbarius* from *lectularius*, the previous division of the material was seen to be somewhat arbitrary from the morphological point of view. The only immediate distinction then to be made was with respect to the host. All the insects found on pigeons and some from fowl-houses had been labelled as *columbarius*. So it seemed best to assume that the insects found on pigeons were perhaps morphologically distinct from *lectularius* and then to find and give quantitative expression to existing, if as yet not precisely recognised, differences. This procedure has been justified, since

bugs from all five localities where pigeon was the host were found to possess, with Jenyns' original type, a characteristically high value for the ratio head-width/length of 3rd antennal segment. Insects from two other places also showed this feature; these were both from fowl-houses, one of which (at Ashen) had previously harboured pigeons. Insects with this high value I have, therefore, called *columbarius*. The others, from Kokstad, had been labelled as *lectularius*, but are intermediate between it and *columbarius*.

From fowl-houses in five other localities insects labelled as *columbarius* possessed values of head-width/3rd antennal segment characteristic of *lectularius*. These I have called *lectularius*. A discussion of the distribution of various values of head-width/3rd antennal segment in *lectularius* and *columbarius* follows later.

As described in another section, I have successfully crossed *columbarius* with *lectularius* and have obtained fertile offspring. In view of this, and in the light of the general morphological differences between the two insects, I propose to regard *C. columbarius* Jenyns as a subspecies of *C. lectularius* L. The insects should thus in future be called *Cimex lectularius* L. subspecies *columbarius* Jenyns and *Cimex lectularius lectularius* L.; throughout this paper I have used the names *lectularius* and *columbarius* to indicate the species and subspecies.

Since this work is primarily of taxonomic interest I have adopted the following general plan in writing the paper :—

1. To show that the ratio 3rd/4th antennal segment is, by itself, unreliable for distinguishing adults of *columbarius* from those of *lectularius*.

2. To describe another character, head-width/3rd antennal segment, which enables a separation to be made and to test its reliability for use with adult insects.

3. To study relative growth in the head and antennae in order to determine if the differences in ratios 3rd/4th and H.W./3rd between *lectularius* and *columbarius* are likely to be due to genetic or environmental factors.

II. Material and Methods.

Most of the adults measured had been in spirit, but a few were dried specimens. All the *lectularius* and *columbarius* in the British Museum (Natural History), the Rothschild Collection at Tring and the London School of Tropical Medicine collection have been measured.

Measurements were made with a monocular microscope. All dimensions in this paper are given in units on an ocular micrometer; 1·0 unit = 0·16 mm. Errors of measurement are not more than 3% for the antennal segments and 1·5% for the head-width. The head-width includes both eyes. Antennae were kept flat by the surface tension of spirit on the micro-slide; Jenyns' type was mounted in balsam. One antenna on each insect was measured.

Both the *lectularius* and the *columbarius* studied during development were bred at 23° C. on rabbit. Two days after moulting a sample was killed with hot water and measured. The insects remaining were fed and those which moulted after the single feed were used for the next sample and for the continuance of the experimental culture. *C. lectularius* used for this purpose came originally from Beckenham (England) and the *columbarius* from Schmeeda (Holland).

An appendix with the list of localities and with numbers of males and females in each sample has been deposited in the library of (1) The British Museum (Natural History), (2) The Imperial Institute of Entomology, (3) The

London School of Hygiene and Tropical Medicine, and (4) The Royal Entomological Society of London. The authorities of the libraries concerned have undertaken to make the list available to students.

III. The Unreliability of the Ratio Length of 3rd/Length of 4th Antennal Segment for Distinguishing Adults of *columbarius* from those of *lectularius*.

A character may be useless for taxonomic purposes in two ways :—

1. Differences in the character, although genetic and of taxonomic significance, may be so slight and may be distributed so evenly throughout a population that they are of little practical use to the systematist.

2. Differences in the character may be due simply to influences of environment or nutrition. Separation of insects into groups on the basis of such a character could be made, but the groups would have no real taxonomic significance.

The two aspects will be considered in order under the headings :—

1. The frequency distributions of 3rd/4th in adults of *lectularius* and *columbarius*.

2. An analysis of the variation of 3rd/4th in adults of *lectularius* and *columbarius*.

1. *Frequency Distributions of 3rd/4th in Adults of* lectularius *and* columbarius.

Jenyns distinguished the two insects by the 3rd and 4th antennal segments which, he maintained, were more nearly equal in length in adults of *columbarius* than in those of *lectularius* (pl. 1). Subsequent writers also have used this character, though usually not in the precise form of a ratio, for the same purpose.

TABLE I.

Frequency distributions, means and standard deviations of the ratio, length of 3rd/length of 4th antennal segment for *lectularius* and *columbarius*. Data from different localities pooled and grouped. For a list of localities see Table II and Appendix.

Values of 3rd/4th	*lectularius*		*columbarius*	
	No.	% of total	No.	% of total
1·05– . . .	4	0·83	—	—
1·10– . . .	1	0·21	10	3·92
1·15– . . .	11	2·27	31	12·16
1·20– . . .	30	6·20	85	33·33
1·25– . . .	79	16·32	68	26·67
1·30– . . .	168	34·71	35	13·73
1·35– . . .	110	22·73	20	7·84
1·40– . . .	56	11·57	4	1·57
1·45– . . .	15	3·10	2	0·78
1·50– . . .	7	1·45	—	—
1·55– . . .	2	0·41	—	—
1·60–5 . . .	1	0·21	—	—
Total .	484	—	255	—
Means .	1·33	—	1·25	—
S.D. . .	0·072	—	0·067	—

Difference of means statistically significant.

I have made frequency distributions of the ratio 3rd/4th with insects from many different localities (Table I, fig. 1); they show that there is such a difference as Jenyns observed, for the modal points of the distributions do not coincide, and the difference between the mean ratios of bugs found with pigeons and those found with man is statistically significant. But the whole *columbarius* distribution is confined within the limits for *lectularius*, and there is no value of the ratio by which individual pigeon-bugs could be distinguished safely from *lectularius*. Jenyns' original type (pl. 1) with a ratio of 1·28 may, on the basis of this character and on the data presented here, be with almost equal chance either *lectularius* or *columbarius*.

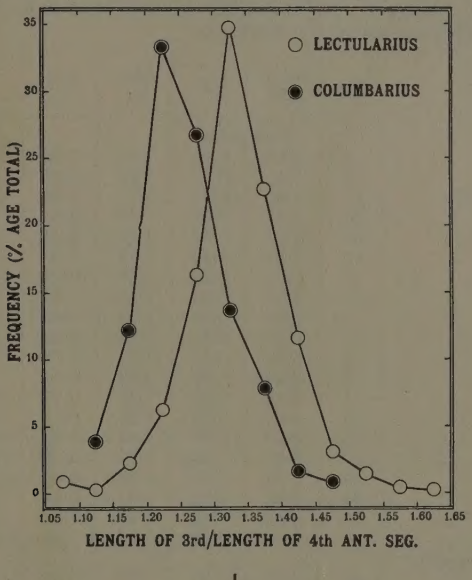

FIG. 1.—Frequency distributions of ratio 3rd/4th antennal segments in *lectularius* and *columbarius*: data in Table I, localities in Table II.

Thus, even if the differences in ratio are entirely genetic, and this is almost certainly not the case, they are too slight and have too much scatter in a population to be of much use to the museum systematist.

2. *An Analysis of the Variation of 3rd/4th in Adults of* lectularius *and* columbarius.

Differences in the value of 3rd/4th are associated with host, size of insect and the locality in which it was found. The association of the ratio differences with host has been considered in the preceding section, and it now remains to study the ratio in respect to the sizes of the insects as measured by the sum of the 3rd and 4th antennal segments and to the localities. Size-ratio association will be considered first: there are two aspects of the relationship.

A. The association of mean values of 3rd/4th with corresponding mean

values of 3rd + 4th from one locality to another (size-ratio association between localities).

B. The association of 3rd/4th with 3rd + 4th between individuals in any one locality (size-ratio association within localities).

A. *Size-ratio association between localities.*

Values of 3rd/4th increase with increase in 3rd + 4th. Tables II and III

TABLE II.

Mean values of 3rd + 4th, 3rd/4th, regression coefficients *b*, and standard deviations for adults of *lectularius* and *columbarius* from various localities. Data for males and females pooled. Values of *b* in italics are significantly different, others not significantly different from zero. Values of *b* for all localities not asterisked do not differ significantly from each other; the same applies to *columbarius*.

Locality	No.	3rd + 4th	S.D.	3rd/4th	S.D.	*b*	S.D.
			lectularius				
*Bgarkent	4	8·48	0·08	1·42	0·02	*0·3000*	0
Dgarkent	9	8·41	0·25	1·46	0·05	0·0551	0·0677
Walthamstow ♀♀	50	7·44	0·29	1·34	0·05	0·0479	0·0470
Berlin	50	7·36	0·31	1·39	0·05	0·0197	0·0222
Geneva R. de C.	55	7·27	0·34	1·38	0·07	0·0032	0·0293
*Macin	14	7·18	0·36	1·33	0·06	*0·0884*	0·0400
Gatooma	10	7·00	0·28	1·29	0·03	−0·0372	0·0411
Tacubaya	35	6·99	0·28	1·31	0·06	0·0377	0·0340
*Eumarella	4	6·90	0·26	1·34	0·06	*0·2192*	0·0731
La Rioja	11	6·89	0·28	1·34	0·09	0·0260	0·0334
*Valetta	14	6·86	0·25	1·34	0·04	−0·0787	0·0428
Athens	9	6·86	0·21	1·33	0·04	0·0328	0·0695
*Wei-Hai-Wei	4	6·85	0·51	1·39	0·07	*−0·1300*	0·0211
Kotagarh	5	6·82	0·23	1·27	0·11	−0·3157	0·1926
Mogador	25	6·69	0·26	1·32	0·04	0·0102	0·0339
*London ♂♂	40	6·62	0·36	1·32	0·09	*0·0896*	0·0356
*Bamenda	40	6·56	0·35	1·28	0·05	*0·0640*	0·0221
*Beckenham	44	6·55	0·22	1·33	0·04	−0·0150	0·0291
Tiberias	13	6·51	0·21	1·26	0·04	0·0759	0·0569
Port Said	20	6·49	0·29	1·32	0·05	−0·0441	0·0374
Beckenham, selected, small ♂♂	28	6·05	0·37	1·27	0·09	−0·0016	0·0495
General means, S.D.'s and Totals	484	6·93	0·55	1·33	0·07	*0·0241*	0·0089
			columbarius				
Kokstad	4	6·58	0·13	1·29	0·06	−0·2259	0·3084
Boxworth (L.S.H.T.M.)	7	6·06	0·35	1·24	0·06	0·1188	0·0596
Boxworth (Roths. Coll.)	46	5·80	0·24	1·27	0·05	0·0554	0·0337
Ashton Wold	7	5·79	0·66	1·23	0·07	*0·0912*	0·0198
Shrewsbury	2	5·75	0·35	1·21	0·05	*0·1429*	0
Frankendorf	4	5·73	0·19	1·25	0·06	0·2475	0·1258
Power Coll.	9	5·71	0·28	1·27	0·07	0·1014	0·0849
Schmeeda	85	5·71	0·23	1·25	0·07	0·0530	0·0311
Ashen (L.S.H.T.M.)	18	5·65	0·21	1·32	0·07	−0·0614	0·0827
Ashen (B.M.)	12	5·63	0·16	1·27	0·05	0·0504	0·0971
Schmeeda (lab.)	61	5·26	0·29	1·22	0·06	*0·0869*	0·0223
General means, S.D.'s and Totals	255	5·63	0·36	1·25	0·07	*0·0708*	0·0139
[Jenyns' type, ♂]	1	5·70	—	1·28	—	—	—

and fig. 2 give the data and illustrate this point. It seems safe to regard the relationship as a linear one expressed by the equation for linear regression

$$Y = \bar{y} + b(x - \bar{x})$$

where Y and $\bar{y}$ are values of 3rd/4th at sizes (3rd + 4th) x and x respectively, and b is the regression coefficient expressing the degree of relationship or the slope of the line between the localities.

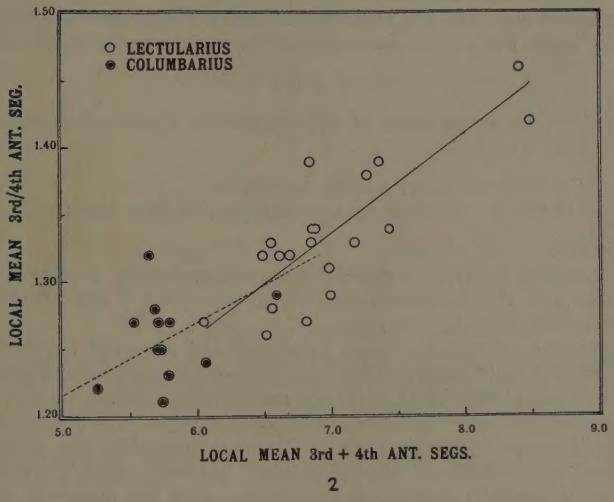

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FIG. 2.—Local means of ratio 3rd/4th antennal segments for *lectularius* and *columbarius*: data in Tables II and III. Regression lines between localities not significantly different in position nor in slope.

TABLE III.

Regression coefficients, b, of 3rd/4th against 3rd + 4th for adults of *lectularius* and *columbarius* from the various localities listed in Table II. The " within " values of b are mean values for the " within " regression coefficients of Table II and n = the number of insects. The " between " values of b express the slopes of the lines between localities and n = the number of groups. Italicised figures are significantly different from zero.

It will be noticed that although the three highest values of b show no statistically significant differences between each other, only two of them are significantly different from the *lectularius* " within " b. It is probably safe to regard this *lectularius* " within " b as different from *columbarius* " between " b in view of

1. the small number of localities for *columbarius*,
2. the difference between the *lectularius* " within " b is greater than the difference between any of the other three values.

The *columbarius* " between " b can perhaps be regarded as truly positive for the same reasons.

		b.	*n*.	S.E.	Sig. tests.
Within	*lectularius*	*0·0241*	484	0·0089	sig.
	columbarius	*0·0708*	255	0·0139	not sig.
Between	*lectularius*	*0·0728*	21	0·0117	not sig.
	columbarius	0·0541	11	0·0306	

not sig. = not sig. / not sig.; sig. = sig. / not sig.; not sig. = not sig. / not sig.

The values of b for between localities are given in Table III and the correlation coefficients of ratio to size in Table VII. The correlation of ratio to size is strong (correlation would be complete if $r = 1$) and neither b nor r is significantly different between *lectularius* and *columbarius*. The slopes of the lines and the scatter about them can, therefore, be regarded as the same for the two insects, and it now remains to find if the positions of the lines are also the same—*i.e.* if one line can represent the association of 3rd/4th with 3rd + 4th between localities irrespective of host.

I determined the expected mean ratio (Y) for a hypothetical population of *columbarius* which has a mean size equal to the mean size for *lectularius*. Thus

$$Y = \bar{y} + b(x - \bar{x})$$

where $y = 1{\cdot}25$, the mean ratio for all *columbarius* whose corresponding mean size (3rd + 4th) $\bar{x} = 5{\cdot}63$.

$x = 6{\cdot}93$, the mean size for *lectularius*.
$b = 0{\cdot}0541$, the regression coefficient (between localities)

for *columbarius*.

Then, assuming linearity of regression for extrapolation, $Y = 1{\cdot}32$, standard error 0·0535, and the *lectularius* mean ratio when 3rd + 4th is $6{\cdot}93 = 1{\cdot}33$, standard error 0·0260.

The expected *columbarius* mean ratio and the observed *lectularius* mean ratio are thus not significantly different at the same mean antennal size, and the differences of ratio between pigeon-bugs and *lectularius* from various localities can be explained to a certain extent as consequent upon size differences. And it is likely that size differences, even if in part heritable, are influenced by environment or nutrition; the character, 3rd/4th, should, therefore, be regarded as of doubtful taxonomic significance until the extent to which size is genetic can be demonstrated.

B. *Size-ratio association within localities.*

Table II lists the regression coefficients of ratio to size within a number of localities for *lectularius* and *columbarius*. Most of them, though positive, are not significantly different from zero, while a few are negative. This suggests that the association of ratio with size is on the whole positive but weak. Mean values of b for within localities given in Table III are significantly different from zero and the corresponding correlation coefficients in Table VII show that there is a significantly stronger relationship of size and ratio in *columbarius* than in *lectularius*.

C. *Differences in 3rd/4th associated with locality.*

Although the general trend of mean local ratios follows local increase in size, there is a considerable scatter of mean values of 3rd/4th about the regression line drawn between localities (Table II and fig. 2). An analysis of co-variance, which eliminates ratio variations due to size differences within localities, reveals that statistically significant ratio differences exist from locality to locality in both *lectularius* and *columbarius*. It is possible that these are not all due to local factors acting directly on the ratio, but are also due to local size differences not eliminated by the analysis of co-variance. The difference in slopes between the regression lines between and within localities rather suggests this (Table III).

Such a state of affairs is illustrated simply in fig. 3, A and B. Local ratio

differences without a corresponding mean size difference are shown in fig. 3, A. Where mean sizes as well as mean ratios are significantly different from locality to locality is shown in fig. 3, B.

Thus it is seen that ratio varies with size in different degrees within localities and between localities, and that it also varies with locality *per se*. It seems likely that ratio differences not associated with size are genetic, while ratio variation due to size differences may be both genetic and environmental. The fact that size-ratio association is different within and between localities suggests that size and, therefore, ratio as affected by size, is partly genetic and

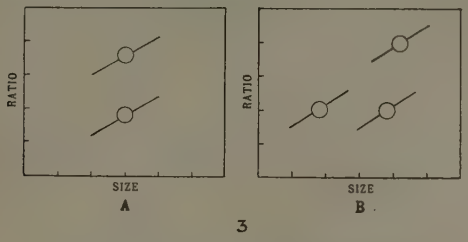

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FIG. 3.—Illustrating hypothetical cases.

A. Mean ratios not associated with size between localities but associated within localities. The regression lines within localities are drawn through each mean.
B. Mean ratios associated with size both within and between localities.

partly environmental, but further analysis must obviously be made by experiment.

IV. The Ratio Head-Width/Length of 3rd Antennal Segment as a Character for Distinguishing *lectularius* and *columbarius*.

1. *Frequency Distributions of H.W./3rd in Adults of* lectularius *and* columbarius.

The frequency distributions in Table IV and fig. 4 show at once that there is a greater distinction between *lectularius* and *columbarius* with H.W./3rd than with 3rd/4th; and by using only those actual insects in the 3rd/4th distribution it can be shown that this greater distinction is not due to the larger number of insects in Table IV.

The chances of distinguishing even individual insects of *columbarius* from *lectularius* appear to be good. If an insect which is supposed to be either *lectularius* or *columbarius* has a certain H.W./3rd it is, of course, not possible to deduce from the present data what the chances are that it is a *columbarius* or a *lectularius*, since the relative frequency with which the two insects can be collected at random in nature is not known. It can only be said that ratios above a certain value (*e.g.* 1·70) appear to be exceedingly rare in natural populations of *lectularius* adults and very common with pigeon-bugs. Jenyns' original type has a ratio of 1·81.

The mean value of H.W./3rd is higher for the insects from animal houses than for the *lectularius* from man. The limits of their frequency distribution, however, fall well within the *lectularius* limits and the general facies of the bugs

is the same as that of *lectularius*. It is possible that in some cases (*e.g.* the insects from Kokstad) interbreeding of *lectularius* and *columbarius* has occurred. But the association of the higher mean ratio value with animal houses may be accidental. This point is discussed later.

TABLE IV.

Frequency distributions, means and standard deviations of head-width/length of 3rd antennal segment for *lectularius* and *columbarius* from various localities and for bed-bugs found in animal- and fowl-houses. Data for sexes pooled and grouped. Kokstad material placed with *columbarius* as well as animal-house bugs.

For a list of localities see Table V and Appendix deposited in Archives.

Grouped values of H.W./3rd	*lectularius*		From animal-houses		*columbarius*	
	No.	% total	No.	% total	No.	% total
1·10– . .	2	0·12	—	—	—	—
1·15– . .	0	0	—	—	—	—
1·20– . .	13	0·75	—	—	—	—
1·25– . .	35	2·03	—	—	—	—
1.30– . .	99	5·75	4	1·14	—	—
1·35– . .	223	12·94	18	5·13	—	—
1·40– . .	416	24·14	36	10·26	1	0·24
1.45– . .	429	24·90	65	18·52	0	0
1·50– . .	319	18·51	107	30·48	0	0
1·55– . .	138	8·01	71	20·23	11	2·69
1·60– . .	34	1·97	30	8·55	20	4·89
1·65– . .	10	0·51	14	3·99	38	9·29
1·70– . .	4	0·23	6	1·71	77	18·83
1·75– . .	0	0	—	—	107	26·16
1·80– . .	0	0	—	—	71	17·36
1·85– . .	1	0·06	—	—	35	8·56
1·90– . .	—	—	—	—	28	6·85
1·95– . .	—	—	—	—	7	1·71
2·00– . .	—	—	—	—	13	3·18
2·05–2·10 .	—	—	—	—	1	0·24
Total .	1723	—	347	—	409	—
Mean .	1·45	—	1·52	—	1·78	—
S.D. .	0·08	—	0·08	—	0·10	—

All means significantly different from each other.

2. *An Analysis of the Variation of H.W./3rd in Adults of* lectularius *and* columbarius.

The frequency distributions show that there is a greater distinction between *lectularius* and *columbarius* with H.W./3rd than with 3rd/4th. The variations in H.W./3rd must now be analysed to find if these too may be associated with size differences in a way which renders them of doubtful taxonomic value.

The adults will be considered first and association of size and ratio during development later. Table V gives values of H.W./3rd, head-width (by which size will be expressed) and regression coefficients for a number of localities. Data for males and females have been pooled for most localities.

Table V.

The within locality regression coefficient b, mean H.W./3rd, mean head-width and their standard deviations for various localities for *lectularius*, *columbarius* and animal-house bugs. All italicised values of b are significantly different from zero. The values of b for all non-asterisked localities for *lectularius* are not significantly different from each other; the same applies to *columbarius* and to animal-house bugs.

Columns 9 and 10 give estimated values of H.W./3rd (Y) for the same head-width (5·878526 = *lectularius* general mean = X) and their standard deviations. This estimate was calculated from the linear regression equation where $\bar{y}$ = the local mean H.W./3rd and $\bar{x}$ = the local mean head-width. Values of b in the equation were mean values of the non-asterisked local values (these were 0·064857, 0·040757 and 0·086327, for *lectularius*, *columbarius* and animal-house bugs respectively), and the local b where asterisked.

Kokstad material included in analysis of both *columbarius* and animal-house bugs.

For a list of details concerning locality and hosts see Appendix in Archives.

Locality	No.	H.W.	S.D.	H.W./3rd	S.D.	b	S.D.	Y	S.D.
				lectularius					
Dgarkent	12	6·42	0·17	1·31	0·060	0·0070	0·1095	1·28	0·017
*Okanagan Landing	3	6·37	0·05	1·49	0·021	*0·3514*	0·0818	1·32	0·040
*Irkutsk	5	6·36	0·17	1·36	0·074	−0·0882	0·2419	1·40	0·124
*Bjarkent	5	6·36	0·34	1·29	0·043	*0·1216*	0·0190	1·23	0·011
Dgarkent	64	6·34	0·32	1·33	0·074	*0·0946*	0·0264	1·30	0·008
Burkhan	1	6·30	0	1·43	0	—	—	1·40	0·060
Asia Minor	1	6·30	0	1·54	0	—	—	1·51	0·060
Möser	1	6·30	0	1·58	0	—	—	1·55	0·060
Magdeburg	10	6·27	0·33	1·41	0·074	0·1064	0·0679	1·39	0·019
Bibianke	1	6·20	0	1·55	0	—	—	1·53	0·060
Waldsassen	10	6·20	0·24	1·41	0·051	0·0931	0·0671	1·39	0·019
*Taucha	18	6·19	0·22	1·47	0·052	*0·1339*	0·0479	1·46	0·012
*London	11	6·17	0·24	1·44	0·072	*0·2173*	0·0696	1·38	0·026
Magdeburg	26	6·15	0·20	1·43	0·047	−0·0037	0·0474	1·42	0·012
Kelowna	33	6·15	0·27	1·47	0·052	0·0306	0·0335	1·46	0·010
*Waldsassen	10	6·14	0·32	1·45	0·067	−0·0738	0·0680	1·46	0·028
*Berlin	50	6·13	0·29	1·43	0·064	*0·1143*	0·0270	1·40	0·010
Magdeburg	3	6·13	0·12	1·41	0·093	0·7285	0·4702	1·39	0·035
*Sydney	4	6·13	0·15	1·50	0·038	−0·0371	0·1781	1·51	0·051
Port Elizabeth	101	6·12	0·28	1·51	0·063	*0·0536*	0·0223	1·50	0·006
London	1	6·10	0	1·42	0	—	—	1·41	0·060
Dorothy	1	6·10	0	1·53	0	—	—	1·52	0·060
Bernberg	41	6·08	0·36	1·46	0·047	0·0320	0·0203	1·45	0·009
Mforgosi	2	6·05	0·05	1·48	0·025	−0·5000	—	1·46	0·042
Troinex	12	6·05	0·22	1·42	0·054	0·1195	0·0676	1·41	0·017
Frankfurt	6	6·05	0·33	1·44	0·042	0·0732	0·0530	1·42	0·024
Liverpool	27	6·04	0·24	1·45	0·068	0·0287	0·0545	1·44	0·012
Waldsassen	7	6·04	0·21	1·49	0·039	0·0717	0·0772	1·48	0·023
Bernberg	58	6·03	0·30	1·46	0·060	0·0185	0·0260	1·46	0·008
Liverpool	6	6·03	0·21	1·51	0·057	*0·2268*	0·0225	1·47	0·006
*Magdeburg	14	6·01	0·28	1·47	0·080	*0·1634*	0·0672	1·45	0·021
Darlinghurst	2	6·00	0·10	1·45	0·005	0·0500	—	1·44	0·042
Colorado	2	6·00	0	1·43	0·03	0	—	1·42	0·042
Geneva R. de C.	55	5·99	0·28	1·43	0·069	*0·0984*	0·0312	1·42	0·008
Gatooma	10	5·99	0·13	1·52	0·054	0·0663	0·1460	1·51	0·019
*Kotagarh	6	5·98	0·22	1·57	0·077	*0·2618*	0·1155	1·54	0·028
Savoie	11	5·98	0·24	1·40	0·042	0·0705	0·0520	1·39	0·018
Norwood	4	5·98	0·33	1·40	0·043	0·0508	0·0266	1·39	0·030
Harrar	11	5·97	0·26	1·45	0·047	0·0284	0·0592	1·44	0·018
Lake Suai	31	5·97	0·28	1·38	0·054	*0·0670*	0·0331	1·38	0·011
*Taucha	10	5·96	0·41	1·45	0·056	*0·1238*	0·0215	1·43	0·009
Zengg	13	5·95	0·21	1·45	0·048	0·0561	0·0682	1·44	0·017
Weiskirch	21	5·95	0·27	1·41	0·051	0·0406	0·0421	1·41	0·013
Macin	15	5·94	0·30	1·45	0·089	0·1029	0·0767	1·44	0·016
Halle	66	5·93	0·23	1·39	0·048	*0·0747*	0·0242	1·38	0·007
*La Rioja	4	5·93	0·15	1·49	0·036	*0·2457*	0·0098	1·47	0·001
Plasupalais, Geneva	54	5·91	0·27	1·38	0·065	*0·0988*	0·0311	1·37	0·008
Waldsassen	54	5·90	0·24	1·46	0·054	*0·0894*	0·0290	1·46	0·008
Eumarella	4	5·90	0·26	1·50	0·093	0·3000	0·3550	1·50	0·030
Durban	15	5·90	0·30	1·53	0·044	0·0561	0·0378	1·52	0·016
Geneva	11	5·90	0·29	1·43	0·068	0·0633	0·0760	1·43	0·018
*Melbourne	36	5·89	0·22	1·47	0·067	*0·1687*	0·0434	1·47	0·010
Port Elizabeth	36	5·88	0·31	1·53	0·066	0·0543	0·0351	1·53	0·010
Port Elizabeth	12	5·87	0·21	1·42	0·061	0·1207	0·0812	1·42	0·017
*Gospic	6	5·87	0·24	1·46	0·026	−0·0594	0·0453	1·45	0·011
Merg	13	5·86	0·29	1·47	0·051	0·0793	0·0474	1·47	0·017
Wei-Hai-Wei	4	5·85	0·30	1·47	0·051	0·0149	0·3747	1·47	0·030
Nogales	5	5·84	0·28	1·40	0·050	*0·1449*	0·0618	1·40	0·027
Wien	11	5·84	0·23	1·37	0·034	0·0135	0·0487	1·38	0·018
Lyme Regis	1	5·80	0	1·38	0	—	—	1·39	0·060
*Tulcea	3	5·80	0·08	1·39	0·039	*−0·4497*	0·1455	1·36	0·016

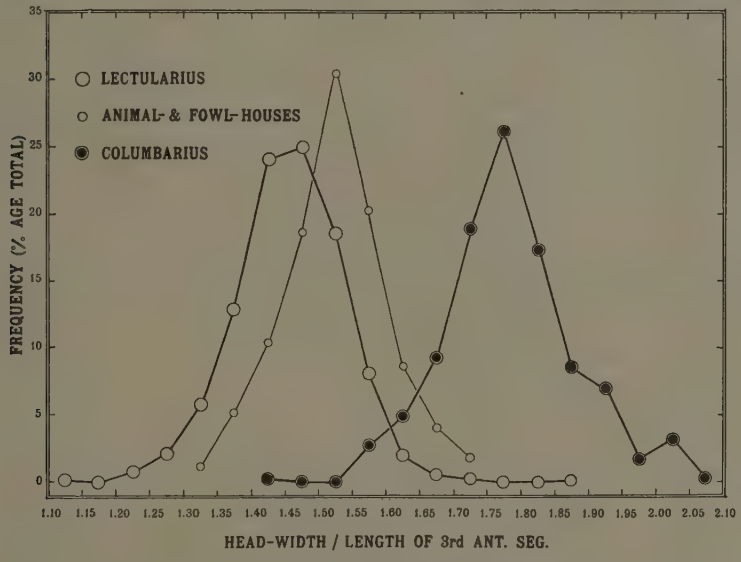
TABLE V—*continued.*

Locality	No.	H.W.	S.D.	H.W./3rd	S.D.	*b*	S.D.	*F*	S.D.
				lectularius					
Lamace	1	5·80	0	1·45	0	—	—	1·46	0·060
Zengg	1	5·80	0	1·49	0	—	—	1·50	0·060
*S. Brisbane	15	5·79	0·20	1·53	0·049	*0·1704*	0·0474	1·54	0·011
Zengg	10	5·78	0·23	1·44	0·044	0·0616	0·0601	1·44	0·019
Annemasse	9	5·78	0·17	1·41	0·064	0·0343	0·1422	1·42	0·020
Tacubaya	36	5·78	0·21	1·46	0·064	0·0954	0·0490	1·47	0·010
*Biskra	3	5·77	0·12	1·44	0·033	*0·2644*	0·0100	1·47	0·002
Athens	9	5·76	0·13	1·47	0·041	0·0385	0·1100	1·48	0·020
Kumarella	4	5·75	0·11	1·49	0·065	0·1615	0·2193	1·49	0·030
Dobrogea	6	5·75	0·24	1·41	0·025	*0·0802*	0·0335	1·42	0·024
La Rioja	22	5·75	0·30	1·46	0·057	*0·0956*	0·0369	1·47	0·013
La Rioja	34	5·74	0·31	1·47	0·070	0·0628	0·0384	1·48	0·010
Papudo	14	5·74	0·22	1·47	0·052	0·0949	0·0616	1·48	0·016
Sorgono	118	5·72	0·24	1·49	0·067	0·0464	0·0255	1·50	0·005
Ain Oussera	6	5·72	0·25	1·38	0·020	0·0382	0·0332	1·39	0·024
La Rioja	1	5·70	0	1·39	0	—	—	1·40	0·060
La Rioja	15	5·69	0·28	1·45	0·048	0·0460	0·0458	1·46	0·016
Port Said	20	5·69	0·25	1·54	0·055	0·0698	0·0488	1·55	0·013
Montevideo	5	5·68	0·29	1·46	0·029	0·0458	0·0501	1·47	0·027
Valetta	13	5·67	0·22	1·44	0·050	*0·1348*	0·0574	1·46	0·017
Saida	2	5·65	0·15	1·40	0·015	0·1000	—	1·41	0·042
Montevideo	5	5·64	0·35	1·48	0·084	0·1379	0·1125	1·49	0·027
Sorgono	54	5·64	0·26	1·47	0·048	0·0230	0·0252	1·48	0·008
*Beckenham	44	5·61	0·24	1·50	0·053	*0·1325*	0·0270	1·54	0·010
Los Culenes	1	5·60	0	1·44	0	—	—	1·46	0·060
La Rioja	4	5·60	0·07	1·42	0·052	0·0500	0·5233	1·44	0·030
Lomaca	8	5·60	0·17	1·48	0·061	0·1909	0·1285	1·49	0·021
Seychelles Islands	9	5·58	0·30	1·51	0·070	0·1055	0·0802	1·53	0·020
*Nicosia	30	5·57	0·22	1·44	0·067	*0·1635*	0·0474	1·49	0·018
Buenos Aires	5	5·54	0·19	1·40	0·016	0·0023	0·0498	1·42	0·027
*Tiberias	13	5·54	0·27	1·53	0·078	*0·1994*	0·0624	1·59	0·027
Mogador	26	5·47	0·26	1·44	0·050	*0·1014*	0·0343	1·47	0·012
Bamenda	39	5·39	0·25	1·47	0·090	0·0836	0·0575	1·50	0·010
*London ♂♂	42	5·39	0·19	1·44	0·080	−0·0521	0·0647	1·42	0·034
Ain Sefra	1	5·30	0	1·43	0	—	—	1·47	0·060
Beckenham, selected, small ♂♂	28	5·08	0·26	1·51	0·080	0·0505	0·0605	1·56	0·011
General means, S.D.'s and Totals	1723	5·88	0·36	1·45	0·079	*0·0735*	0·0054	1·45	0·0094
				columbarius					
Kokstad	4	6·08	0·15	1·64	0·053	*0·3200*	0·1360	1·63	0·042
Schmeeda ♀♀	44	5·94	0·18	1·86	0·096	0·0152	0·0837	1·86	0·013
Ashton Wold	7	5·86	0·26	1·86	0·220	0·0069	0·3618	1·86	0·032
Boxworth (Roths.)	46	5·78	0·20	1·79	0·085	*0·1293*	0·0601	1·80	0·012
Ashen (L.S.H.T.M.)	19	5·76	0·21	1·79	0·059	0·0990	0·0631	1·79	0·019
Boxworth (Roths.)	151	5·75	0·24	1·78	0·073	0·0133	0·0249	1·78	0·007
*Shrewsbury	2	5·70	0·20	1·82	0·080	−0·40	—	1·89	—
*Schmeeda ♂♂	41	5·67	0·16	1·81	0·083	*0·2900*	0·0717	1·87	0·019
*Power Colln.	9	5·67	0·21	1·78	0·068	−0·1369	0·1149	1·81	0·034
Boxworth (L.S.H.T.M.)	8	5·64	0·32	1·69	0·076	0·0070	0·0958	1·70	0·030
Frankendorf	4	5·48	0·25	1·73	0·037	−0·0131	0·1047	1·74	0·042
Ashen (B.M.)	15	5·45	0·22	1·74	0·048	*0·1217*	0·0482	1·75	0·022
*Ashen & B.M.	2	5·35	0·07	1·70	0·035	−0·7000	—	2·06	—
Schmeeda (lab.)	57	4·92	0·25	1·70	0·094	0·0480	0·0503	1·74	0·011
General means, S.D.'s and Totals	409	5·64	0·38	1·78	0·096	*0·0479*	0·0185	1·79	0·0173
[Jenyns' type, ♂]	1	5·80	—	1·81	—	—	—	—	—
				Animal houses					
Kokstad	4	6·08	0·15	1·64	0·053	*0·3200*	0·1360	1·62	0·031
Taucha	20	5·97	0·35	1·39	0·045	0·0496	0·0557	1·38	0·014
Edinburgh (Slack)	18	5·93	0·23	1·51	0·080	0·1643	0·0757	1·51	0·014
Port Elizabeth	23	5·92	0·27	1·49	0·080	*0·1464*	0·0569	1·49	0·013
Lostan	70	5·92	0·23	1·57	0·062	0·1270	0·0283	1·57	0·007
Albany, N.Y.	4	5·80	0·19	1·49	0·037	0·0014	0·1414	1·50	0·031
East Greenbush	1	5·80	0	1·49	0	—	—	1·50	0·062
Lostan	109	5·79	0·24	1·53	0·061	0·0939	0·0719	1·54	0·006
London (Greenwich)	52	5·78	0·32	1·48	0·065	0·0576	0·1653	1·49	0·008
Mexico	50	5·29	0·23	1·53	0·069	0·0656	0·0424	1·58	0·009
General means, S.D.'s and Totals	351	5·77	0·32	1·52	0·079	*0·0863*	0·0125	1·53	0·0215

A. *Size-ratio association between localities.*

The regression coefficient of mean H.W./3rd with mean H.W. from locality to locality is negative for *lectularius* and positive for *columbarius*. These coefficients are significantly different from zero and from each other; the correlation is quite strong for *columbarius* but rather weak for *lectularius* (Tables VI and VII).

Thus as the mean head-width increases from locality to locality the mean ratio increases for *columbarius* but decreases for *lectularius*. The regression lines converge but, with the data here, never meet (fig. 5), and even at the small head-widths, where they come most close together, their mean ratios are significantly different. This is seen if the mean ratio for the *columbarius* of



4

FIG. 4.—Frequency distributions of ratio H.W./3rd in *lectularius*, *columbarius* and *lectularius* from animal- and fowl-houses: data in Table IV, localities in Table V.

smallest mean head-width (Schmeeda, lab. bred) is compared with an estimated *lectularius* ratio at the same head-width.

$$Y = \bar{y} + b(X - \bar{x}) \text{ where}$$

Y = estimated *lectularius* ratio at head-width X.
X = 4·92, the *columbarius* minimum mean head-width.
$\bar{y}$ = the observed *lectularius* mean ratio (1·45) at head width $\bar{x}$.
$\bar{x}$ = the observed *lectularius* mean head-width (5·88).
b = the between localities regression coefficient for *lectularius* (—0·0454)

Then assuming linearity for extrapolation Y = 1·50, S.D. = 0·002.

The observed *columbarius* ratio at the same head-width (4·92) is 1·70 (S.D. = 0·0510). The difference between this and the estimated *lectularius* ratio is therefore statistically significant.

Thus the effects on ratio of local differences in head-width do not in themselves appear to render populations of *lectularius* and *columbarius* adults at certain common head-widths indistinguishable from each other.

B. *Size-ratio association within localities.*

The ratio H.W./3rd increases with increase in head-width within localities in both *lectularius* and *columbarius* (Tables V and VI) and the general correlation

TABLE VI.

Between localities and mean within localities regression coefficients, *b*, of H.W./3rd against H.W., and their standard deviations, for adults of *lectularius* and *columbarius*. Italicised figures are significantly different from zero. *n* (within) = number of insects; *n* (between) = number of groups.

		b	*n*	S.E.	Sig. tests.
Within	*lectularius*	*0·0735*	1723	0·0054	not sig.
	columbarius	*0·0479*	409	0·0185	
Between	*lectularius*	*−0·0454*	97	0·0198	sig.
	columbarius	*0·1149*	14	0·0305	

sig. + not sig. → not sig.

TABLE VII.

Correlation coefficients, *r*, of 3rd/4th against 3rd + 4th and of H.W./3rd against H.W. for adults of *lectularius*, *columbarius* and *lectularius* from animal-houses. Within values are means. Italicised figures are significantly different from zero.

n for between localities = number of groups.
n for within localities = number of insects.

$$\text{S.D.} = \frac{1}{\sqrt{n-3}}.$$

		r	*z*	*n*	S.D.	Sig. tests
		3rd/4th against 3rd + 4th				
lectularius	within	*0·1245*	0·1252	484	0·0456	sig.
	between	*0·8202*	1·1575	21	0·2356	
columbarius	within	*0·3104*	0·3210	255	0·0630	not sig.
	between	0·5098	0·5624	11	0·3536	
		H.W./3rd against H.W.				
lectularius	within	*0·3125*	0·3230	1723	0·0241	sig.
	between	*−0·2292*[1]	−0·2334	97	0·1031	
lectularius from animal-houses	within	*0·3471*	0·3622	351	0·0536	not sig.
	between	−0·0490	−0·0490	10	0·3780	
columbarius	within	*0·1275*	0·1282	409	0·0496	sig.
	between	*0·7363*	0·9324	14	0·3015	

sig. + not sig. → not sig.

[1] $P > 0{\cdot}02$ in Fisher's Table V.A. and therefore not significant.

and regression coefficients are significantly different from zero. The association is not very strong, but differs significantly between the two insects.

C. *Differences in H.W./3rd associated with locality.*

There is a large scatter of mean local ratio values about the regression lines between localities (fig. 5). An analysis of co-variance which eliminates the

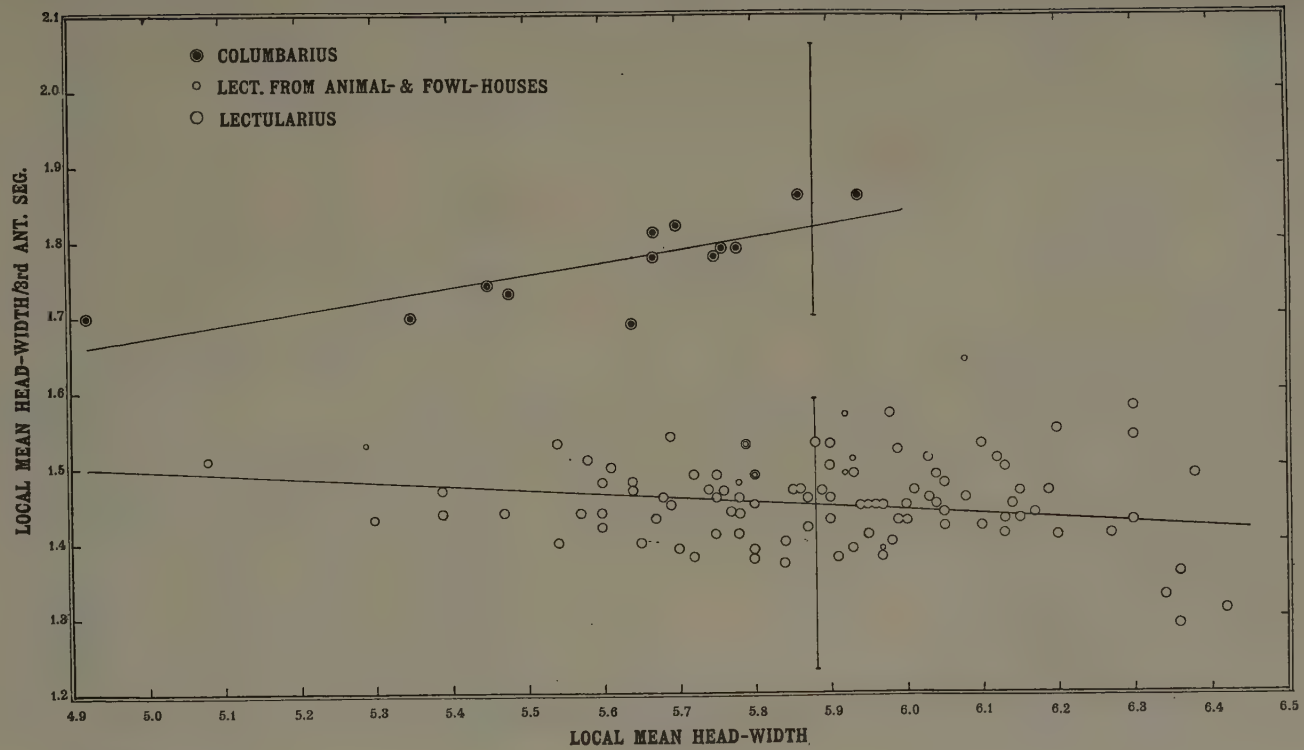


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FIG. 5.—Local means of ratio H.W./3rd and of H.W. for *lectularius*, *columbarius* and *lectularius* from animal- and fowl-houses. Regression lines between localities for *lectularius* from man and *columbarius* are drawn. They include Russian and Kokstad material respectively. Vertical lines are drawn between the limits for mean H.W./3rd at mean *lectularius* head-width after correction for within locality effect of size. Data in Tables V and VI.

within localities size-effect on ratio reveals that considerable local differences in mean values of ratio exist independently of the H.W. variation within localities. From the mean values of the estimated ratios it can be seen that there are very many differences between them which are statistically significant. The mean values of these estimates for *lectularius*, *columbarius* and animal-house *lectularius* are significantly different from each other.

V. Changes in the Ratios 3rd/4th and H.W./3rd During Development from 1st Instar to Adult in *lectularius* and *columbarius*.

The ratio 3rd/4th increases considerably in size from instar to instar in both *lectularius* and *columbarius* (Table VIII; fig. 6). The slopes of the curves are the same (Table IX), although their positions are significantly different; the

TABLE VIII.

Association of ratio 3rd/4th with 3rd + 4th throughout development, in *lectularius* and *columbarius*.

	lectularius			*columbarius*		
	3rd+4th	3rd/4th	No.	3rd+4th	3rd/4th	No.
Instar 1 . . .	3·47	0·78	20	3·08	0·82	20
,, 2 . . .	4·02	0·96	19	3·30	0·90	21
,, 3 . . .	4·68	1·02	20	3·78	0·97	20
,, 4 . . .	5·41	1·14	20	4·32	1·08	23
,, 5 . . .	6·08	1·24	20	—	—	—
Adult ♂ . . .	6·40	1·34	20	5·09	1·21	29
,, ♀ . . .	6·67	1·32	24	5·41	1·24	32
Adults ♂ and ♀ . .	6·54	1·33	44	5·25	1·23	61
Means and totals.	5·29	1·12	143	4·32	1·06	145
S.D. . . .	1·153	0·195	—	0·905	0·161	—

TABLE IX.

Regression and correlation coefficients b and r respectively for 3rd/4th against 3rd + 4th during development from 1st instar to adult in *lectularius* and *columbarius*.

n for within = number of insects.

n for between = number of development groups (5 instars + ♂ and ♀ adults except for *columbarius* where 5th instar not measured).

Italicised figures are significantly different from zero.

		b	n	S.D.	Sig. tests
lectularius	within	0·0319	143	0·0230	sig.
	between	*0·1652*	7	0·0111	sig.
columbarius	within	*0·1083*	145	0·0149	sig.
	between	*0·1756*	6	0·0066	sig.
					not sig.
					sig.

		r	z	n	S.D.	Sig. tests
lectularius	within	0·1159	0·1164	143	0·0845	sig.
	between	*0·9890*	2·5986	7	0·5000	sig.
columbarius	within	*0·4894*	0·5353	145	0·0893	sig.
	between	*0·9970*	3·0 approx.	6	0·5774	sig.
						not sig.
						sig.

TABLE X.

Association of ratio H.W./3rd with H.W. throughout development in *lectularius* and *columbarius*.

	lectularius			*columbarius*		
	H.W.	H.W./3rd	No.	H.W.	H.W./3rd	No.
Instar 1 . .	2·32	1·53	11	2·20	1·58	20
,, 2 . .	2·81	1·43	19	2·51	1·61	21
,, 3 . .	3·44	1·46	20	3·02	1·63	20
,, 4 . .	4·17	1·45	20	3·70	1·65	23
,, 5 . .	4·95	1·47	20	—	—	—
Adult ♂ . .	5·39	1·47	20	4·71	1·70	27
,, ♀ . .	5·80	1·53	24	5·10	1·71	30
Adults ♂ and ♀ .	5·60	1·50	44	4·91	1·71	57
Means and totals	4·30	1·48	134	3·70	1·65	141
S.D. . .	1·184	0·060	—	1·109	0·089	—

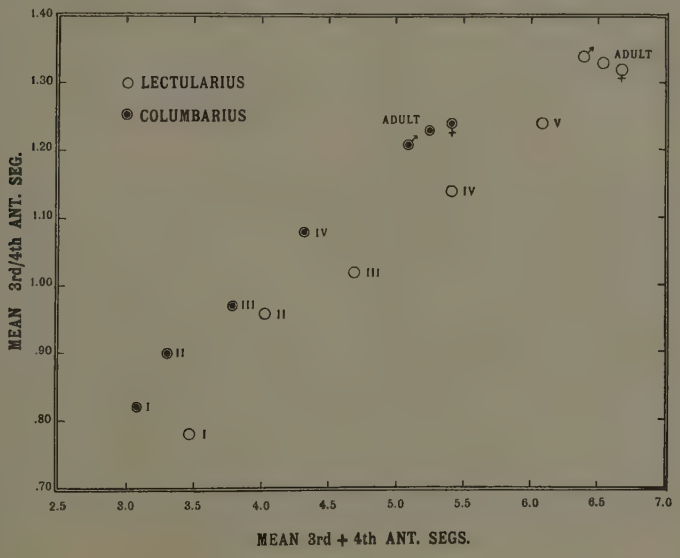

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FIG. 6.—Association of ratio 3rd/4th with 3rd + 4th (size) during development in *lectularius* (lab. bred from Beckenham) and *columbarius* (lab. bred from Schmeeda). Numbers beside points denote instars. Data in Table VIII.

correlation of ratio with size is very strong (Table IX). The reason for the change in ratio during development is due to the different growth rates of the two antennal segments (Table XIII, fig. 8).

The ratio H.W./3rd does not change appreciably during development in *lectularius* and increases in value only slightly in *columbarius* (Tables X and

Table XI.

Regression and correlation coefficients, *b* and *r*, respectively, for H.W./3rd against H.W. during development from 1st instar to adult in *lectularius* and *columbarius*.

n for within = number of insects.

n for between = number of development stages (5 instars + ♂ and ♀ adults. 5th instar not measured for *columbarius*).

Italicised figures are significantly different from zero.

		b	*n*	S.D.	Sig. tests
lectularius	within	*0·1903*	134	0·0374	sig.
	between	0·0109	7	0·0100	sig.
columbarius	within	*0·1362*	141	0·0499	not sig.
	between	*0·0420*	6	0·0017	sig.

		r	*z*	*n*	S.D.	Sig. tests
lectularius	within	*0·5545*	0·6349	134	0·0873	not sig.
	between	0·3863	0·4074	7	0·5000	
columbarius	within	*0·2255*	0·2295	141	0·0851	sig.
	between	*0·9943*	2·9282	6	0·5774	

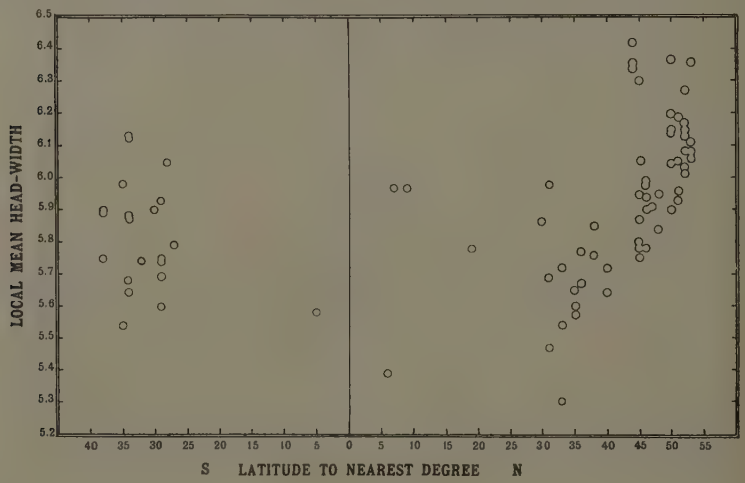

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Fig. 7.—Variation of mean local head-width with latitude in *lectularius*. Data in Table V and Appendix.

XI.). This is because the head-width and 3rd segment grow at approximately the same rate (fig. 8). The antenna as a whole (2nd + 3rd + 4th segments, small 1st seg. omitted) also increases in length relatively as fast as the head increases in width in *lectularius*. In *columbarius* the head grows a little faster relative to the whole antenna, and to the 3rd segment; this produces the increase in ratio value during development.

VI. Geographical Variations in *lectularius*.

With the small number of insects and samples at my disposal it is possible for only a very superficial study of the geographical distribution of variations to be made

The means of the larger *lectularius* samples, where the localities are recorded in the gazetteer, were arranged against the latitude to the nearest degree; laboratory bred and selected insects were not used. In view of the domestic habits of *C. lectularius* with the relative absence of contact with extreme climatic changes I did not expect a very definite result. In the northern hemisphere, however, the head-width and the length of 3rd antennal segment are quite strongly correlated with latitude (fig. 7); bugs from the more northern latitudes have wider heads and longer 3rd antennal segments (the size of the whole insect probably varies) with unweighted correlation coefficients of 0·5106 and 0·4737 respectively. Both these coefficients are significantly different from zero ($P = < 0{\cdot}01$). The scatter diagram for the southern hemisphere show no obvious correlation and the coefficients were not calculated. This absence of correlation may be due to the small number of samples; it can scarcely be because an insufficient time has elapsed since the comparatively recent introduction of the insect south of the equator for geographical variation to become well marked, for much of the variation is, in all probability, due to climate.

A scatter diagram of H.W./3rd (corrected for H.W. differences within localities) against latitude was made and no obvious correlation worthy of further investigation was revealed.

VII. Cross-Breeding of *lectularius* and *columbarius*.

I have crossed *lectularius* males with *columbarius* females and have obtained fertile hybrids. Fertile hybrids from the reciprocal cross have also been obtained. Virgin insects, both male and female, were used for these experiments and were kept singly in tubes before moulting into the adult stage.

There appears to be no more difficulty in producing these hybrids than in breeding the *columbarius* parents. Even when the sizes of male and female parents are very dissimilar the hybrids can still be obtained. The chief difficulty is in feeding the *columbarius* parents, but when this has been accomplished egg-production rarely fails to occur.

The hybrids show no reluctance to feed. I have not bred them beyond the F_2 generation, but F_1 hybrids are fertile with themselves and with *lectularius*. Hase (1938) has also crossed *lectularius* with a *Cimex* from a pigeon-house. A description of the morphology of the pigeon-bug was not given, although doubtless it was *columbarius*.

VIII. Discussion on the Taxonomic Significance and on the Causes of the Variations of the Ratios 3rd/4th and H.W./3rd.

The comparatively few records of the occurrence of *columbarius* rarely contain measurements of the insects. The most complete set of metrical data is that of Moens (1925) for bugs found on starlings. By comparing the 3rd and 4th antennal segments Moens concluded that these insects were *columbarius*. It has been shown above, however, that the ratio of these segments by itself is of little use for identification. I have analysed Moens' data; for the 30

antennae measured the mean of 3rd/4th is 1·31 (S.D. = 0·10) and the mean 3rd + 4th is approximately 6·7 in the units used in this report. Thus the mean ratio is not significantly different from the *lectularius* and it is significantly different from the *columbarius* mean ratio (Table II). The value of 3rd + 4th is also too high for *columbarius*. It may be supposed, therefore, that Moens' data deal with *lectularius* and not with *columbarius*.

Other numerical data have been published by Slack (1937) on bugs from rat-cages. These bugs were thought to be more typical of *columbarius* than of *lectularius* on the evidence of the ratio of 3rd and 4th antennal segments alone. In a later publication (Slack, 1938) bugs, presumably from the same culture, were spoken of as a subspecies of *Cimex* " phenotypically intermediate between *C. lectularius* and *C. columbarius*." I have measured some of this material, now in the British Museum (Natural History). The mean ratio and mean sum of the 3rd and 4th segments for 17 insects are as follows :—

3rd/4th	S.D.	3rd + 4th	S.D.
1·37	0·07	6·82	0·23

If these data are compared with general means in Table II it is seen that while the ratio 3rd/4th for Slack's material is significantly different neither from *lectularius* nor from *columbarius*, the ratio tends towards the *lectularius* type. The value for 3rd + 4th is, moreover, not significantly different from the *lectularius*, although it is from the *columbarius* value.

The mean head-width of Slack's material does not differ significantly from the general mean head-widths of either *lectularius* or *columbarius* (Table V). But the mean H.W./3rd does differ significantly from the mean value for *columbarius*, although not from the *lectularius* mean. It thus appears that Slack's insects should be regarded as *lectularius* although, like some of the bug populations from fowls (Table V), the mean H.W./3rd is rather high. Yet these high ratios all fall within the limits for *lectularius*, and their high values may be due to sampling errors; such insects cannot, therefore, be regarded as true intermediate types. The insects described by Girault and Strauss (1905) and Girault (1913) were thus probably *lectularius*, and this was Horvath's view (Butler, 1923). The Kokstad material seems to be an exception, and its mean H.W./3rd is intermediate between *lectularius* and *columbarius*.

Thus there is no evidence that *lectularius* fed on fowls become like *columbarius* or that *columbarius* fed on mammals assume the characters of *lectularius* as suggested by Eichler (1937) and Slack (1937). In addition to the data from wild populations, I have a certain amount of experimental evidence that the characters do not change with host. *C. columbarius* from the original wild stock from Schmeeda were bred at 23° C. and fed on rabbit side by side with *lectularius* for 3–4 generations. Their mean H.W./3rd was certainly smaller than the original wild stock, but can be accounted for by the decrease in size of bugs in the laboratory culture. If the sexes are pooled then the parameters are

	H.W.	H.W./3rd	*b*
wild stock	5·81	1·84	0·1505
lab. stock	4·92	1·70	

The expected ratio for a mean head-width of 4·92 in the wild stock is 1·71 compared with the observed value 1·70 for the laboratory insects. Moreover,

assuming linearity of regression when extrapolating the *lectularius* ratio (1·45) cannot be approached by a further diminution of size, since for such a ratio the head-width would be 3·22, far smaller than for any typical *lectularius*.

The probable causes of ratio and size differences may now be considered. Only experiment can decide finally the degree to which such variations are genetic or environmental, but certain speculations may be made. The ratio 3rd/4th and the sum of the 3rd and 4th antennal segments will be considered first.

From Table VIII and fig. 6 it is seen that the 3rd and 4th segments grow allometrically. Any environmental factor depressing growth so as to produce small adults would, therefore, also produce small ratios. Variations in size and ratio in adults both within and between localities are undoubtedly in part due to such influences, but it seems probable that size differences between *lectularius* and *columbarius* are also partly heritable and carry with them ratio variations. Local ratio differences associated with the local size differences not eliminated by the analysis of co-variance probably belong to this category. An experimental basis exists for regarding size differences between *lectularius* and *columbarius* as partly genetic, for I have bred *columbarius* at 23° C. on rabbit for 7 to 10 generations over a period of 21 months and they are still much smaller than the *lectularius* bred side by side with them under identical conditions. Such smallness may be associated with the greater reluctance of *columbarius* to feed, whether the host is pigeon, fowl, rabbit or man. For a strict comparison, however, the insects should be bred, not necessarily at the same temperature, but at the temperatures at which their maximum sizes are respectively attained. Size variation in *lectularius* is also associated with the latitude of their locality (fig. 7 and Appendix). Presumably climatic factors account for this, in spite of the relative protection of such domestic insects from great climatic fluctuations.

Allometry is of less importance in assessing the taxonomic significance of H.W./3rd, since this ratio remains constant during development in *lectularius* although it increases slightly during development in *columbarius*. A depression of growth with the production of small adults would, therefore, presumably have no effect on the ratio in *lectularius* and only a slight effect with *columbarius*. The relative independence of H.W./3rd of size can be expressed quantitatively if the regression coefficient of ratio against head-width is expressed as a percentage of the associated mean ratio. The size-effect on 3rd/4th and H.W./3rd can then be compared (Table XII), and it is seen that, during development, 3rd/4th is much more influenced by size than is H.W./3rd. Thus,

TABLE XII.

Regression coefficients, *b*, of 3rd/4th on 3rd + 4th and H.W./3rd on H.W. for *lectularius* and *columbarius* expressed as percentages of their respective mean ratio values. This percentage enables the effects of size on the two ratios to be compared.

Regression throughout development from 1st instar to adult.

		Between instars		*b* as % mean ratio
		Mean ratio	*b*	
lectularius	3rd/4th	1·12	0·1652	14·62
	H.W./3rd	1·48	0·0109	0·74
columbarius	3rd/4th	1·06	0·1756	16·57
	H.W./3rd	1·65	0·0426	2·55

assuming that environment has no direct effect on the proportions of head-width and length of 3rd antennal segment in the egg, the ratio H.W./3rd is not likely to vary greatly with external conditions.

It is convenient to consider variations in *lectularius* first. Variations in ratio—*i.e.* in relative proportion of head-width and length of 3rd antennal segment are those :—1. Associated with size (H.W.); 2. not associated with size.

Variations in ratio associated with size are seen in adults *within* localities, where the larger ratios accompany large head-widths. It seems most probable that these variations in relative width of head and length of 3rd segment originate within the egg. Ratios in the instars show similar correlation with head-width as in the adults.

Significant variations in local mean ratio also exist, which are independent of the within locality size-effects. These may, however, be associated with local variations in head-width not eliminated by the analysis of co-variance, for there is also a significant correlation of head-width and ratio between localities, and the limits of head-width of many localities do not overlap. This correlation coefficient ($r = -0{\cdot}23$; $n = 97$) is negative and a *decrease* in H.W./3rd follows increase in local mean head-width. (See Sumner (1932) for similar inconsistent inter- and intra-racial correlations.)

The position is greatly simplified if the 5 samples from Russia (Dgarkent, Burkhan, and Irkutsk), which stand out in their possession of very low ratios, are segregated. The correlation and regression coefficients between the remaining 92 localities do not then differ significantly from zero ($r = -0{\cdot}1183$; $b = -0{\cdot}02$; S.D. of $b = 0{\cdot}05$) and the ratio remains constant over a wide range of head-width. An analysis of co-variance on the remaining 92 localities shows that although significant differences not associated with within locality size variations occur ($z = 0{\cdot}2878$; degrees of freedom 1543 and 91), they are not so pronounced as when the Russian material was included and $z = 1{\cdot}3280$ (degrees of freedom = 1625 and 96). The Russian insects were, therefore, responsible for most of the variation in ratio exhibited in the original 97 samples. Now these Russian insects have very wide heads, probably due to climate, but they are not much wider than the widest of the remaining 92 samples. And the ratios are strikingly low (fig. 5) because the 3rd antennal segments are much longer than would be expected simply in virtue of the large sizes of the insects. The Russian insects are thus probably a distinct type of *lectularius*, although their ratio variation is similar to though more pronounced than the local types of the remaining group.

Whether this variation is genetic or environmental is not known. But if two sets of genes control head-width and 3rd antennal segment respectively the factors operating on them to produce variation in relative length must be different within and between localities. It has been suggested (Richards, 1938) that where, as in the present case, the correlation is of the " presence or absence " type and although both characters (H.W. and 3rd segment) are present, there is no correlation in the extent to which they are developed, the differences are almost entirely genetic. Whereas in a normal correlation, such as found within localities, variations are mainly due to environment. It appears that the original group of 97 samples is heterogeneous and that heterogeneity is decreased by the segregation of the Russian material; for the correlation co-efficient between the Russian localities is $-0{\cdot}4084$ and, although not significantly different ($P = 0{\cdot}8$ approx.) from the correlation coefficient between the original 97 localities ($r = -0{\cdot}2292$), is larger. If it was significantly larger

it would also suggest (Richards, 1938) that the Russian insects were of a distinct genetic type.

Variations of H.W./3rd occur in *columbarius* similar to those in *lectularius*, but allometry, and with it the effect of environment, are additional factors. An analysis of co-variance still leaves significant differences in ratio ($z = 0{\cdot}9581$; 344 and 9 degrees of freedom), but unlike the 92 *lectularius* samples, these are probably associated with local head-widths not eliminated by the analysis; and since head-width may be environmentally determined these ratio differences may be partly environmental too.

The differences between *lectularius* and *columbarius* may now be considered and may be attributed to :—

1. Allometry in *columbarius* but not in *lectularius*, where the head-width increases relatively faster than the 3rd antennal segment (and also faster than the whole antenna) during development. This produces higher ratios in the adults than in the instars (Table X, fig. 8).

TABLE XIII.

Mean dimensions of 2nd, 3rd and 4th antennal segments and head-widths of *lectularius* (Beckenham) and *columbarius* (Schmeeda) throughout development and percentage increases at each stage from the dimensions of the 1st instar.

Instar	Antennal segments.						2nd + 3rd + 4th	%	H.W.	%	No.
	2	%	3	%	4	%					
					lectularius						
I	0·94	0	1·52	0	1·95	0	4·41	0	2·32	0	11
II	1·27	35·1	1·96	28·9	2·05	5·1	5·28	19·7	2·81	21·1	19
III	1·75	86·2	2·37	55·9	2·31	18·5	6·43	45·8	3·44	48·3	20
IV	2·33	147·9	2·88	89·5	2·54	30·3	7·75	75·7	4·17	79·7	20
V	3·00	219·1	3·36	121·1	2·72	39·5	9·08	105·9	4·95	113·4	20
Adult ♂	3·59	281·9	3·66	140·8	2·74	40·5	9·99	126·5	5·39	132·3	20
,, ♀	3·78	302·1	3·80	150·0	2·87	47·2	10·45	137·0	5·80	150·0	24
Adults ♂ and ♀	3·69	292·6	3·73	145·4	2·81	44·1	10·22	131·7	5·60	141·4	44
					columbarius						
I	0·77	0	1·39	0	1·69	0	3·85	0	2·20	0	20
II	1·03	33·9	1·56	12·2	1·74	3·0	4·34	12·7	2·51	14·1	21
III	1·35	75·3	1·86	33·8	1·92	13·6	5·13	33·2	3·02	37·3	20
IV	1·73	124·7	2·24	61·2	2·07	22·5	6·04	56·9	3·70	68·2	23
V	—	—	—	—	—	—	—	—	—	—	—
Adult ♂	2·53	228·6	2·79	100·7	2·30	36·1	7·62	97·9	4·71	114·1	27
,, ♀	2·74	255·8	2·99	115·1	2·42	43·2	8·16	111·9	5·10	231·8	30
Adults ♂ and ♀	2·64	242·9	2·89	107·9	2·36	39·6	7·89	104·9	4·91	123·2	57

2. The effect of environment on ratio, acting through size in *columbarius* but not in *lectularius*.

3. Possible genetic size differences.

4. Differences in the ratio *per se* originating within the egg; the ratio means of 1st instars of *lectularius* and *columbarius* are significantly different.

Judging from only one example each of *lectularius* and *columbarius*, an essential distinguishing feature between the two insects which is not likely to be due to environment is the presence of allometric growth during development in the head and antennae of *columbarius* and its absence in *lectularius*. Another possibly genetic difference may be the different relative proportions of head-width and 3rd antennal segment between the two insects originating in the egg, which is similar to, though more pronounced than, the local variations in ratio in *lectularius* not associated with size variations.

The other factor making for local differences in H.W./3rd is the unequal number of males and females in the samples at my disposal (see Appendix in

Archives). A preliminary analysis of sex differences in H.W./3rd for the largest groups was made, but in only 2 cases out of 8 were male and female regression lines of H.W./3rd against head-width significantly different in position. In 6 of the 8 cases, although the lines were not significantly distinct, the males had a very slightly higher ratio. Most samples were too small to analyse for such sex differences, and I do not think they have had much effect, for one sex did not usually predominate to an extent likely to weight the mean significantly.

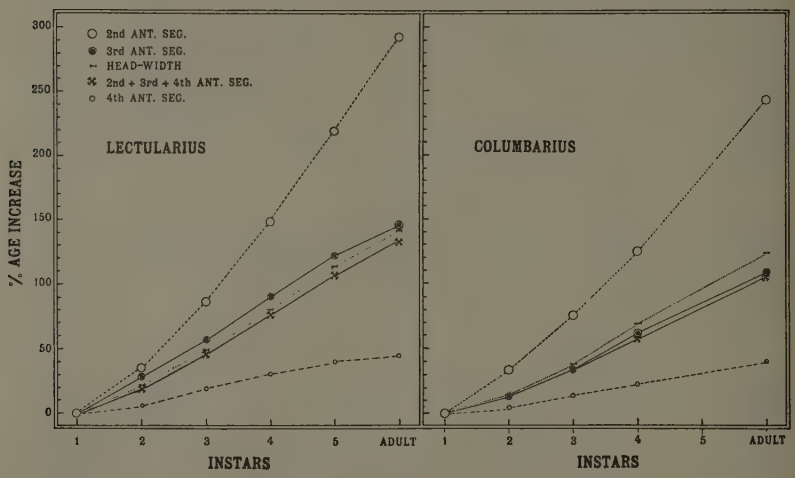

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FIG. 8.—Percentage increase throughout development in antennal length, length of each antennal segment (except the small 1st segment) and head-width from original values in 1st instar. Data in Table XIII. *lectularius* lab. bred from Beckenham, *columbarius* lab. bred from Schmeeda.

IX. Summary.

1. The pigeon-bug, *Cimex columbarius* Jenyns, resembles the bed-bug, *C. lectularius* L., so closely that many workers have thought that they are the same species : identification has been very difficult.

2. The most important character which has hitherto been used for distinguishing *C. columbarius* from *C. lectularius* is the difference in proportion of the 3rd and 4th antennal segments. The means of the ratio, length of 3rd/length of 4th antennal segment differ significantly between *C. lectularius* and *C. columbarius*, but their frequency distributions overlap completely. The character 3rd/4th is, therefore, of little use for taxonomic purposes.

3. The 3rd and 4th antennal segments grow allometrically during development and their proportions vary according to the size of the adults. Environment will, therefore, influence the value of the ratio, if it produces different sized adults.

4. But adults of *C. columbarius* are smaller, on the whole, than those of *C. lectularius*, and this size difference is thought to be partly genetic. Thus ratio 3rd/4th may be heritable in virtue of size inheritance.

5. Size differences between localities in adults of either *C. lectularius* or *C. columbarius* may be partly environmental, but regression lines of 3rd/4th on 3rd + 4th (size) between localities are not significantly different in slope nor in position for adults of the two insects. Thus *C. lectularius* and *C. columbarius* adults of the same size will tend to have same values for 3rd/4th.

6. An analysis of co-variance reveals that significant local differences in ratio exist for which within locality size variations are not responsible. These ratio differences may, however, be associated with the size differences between localities not eliminated by the analysis.

7. A new distinguishing feature (head-width/length of 3rd antennal segment) has been found which enables a fairly satisfactory separation of *C. columbarius* from *C. lectularius* to be made. The frequency distributions of this ratio for the two insects overlap but slightly.

8. During development, H.W./3rd does not vary with the size of the insect, as expressed by head-width, in *C. lectularius* since the H.W. and 3rd segment have equal growth rates. Although the H.W./3rd is correlated with H.W. in the adults within localities, the two characters are largely uncorrelated between localities. Local ratio differences not associated with size variations occur and these are possibly genetic.

9. H.W./3rd increases slightly with increase of H.W. during development in *C. columbarius*. Environment is, therefore, likely to alter the value of this ratio. The increase of ratio with increased head-width both within and between localities may be largely due to environmental influences.

10. The differences in value of H.W./3rd between adults of *C. lectularius* and *C. columbarius* are due to :—

a. Differences due to allometry of the H.W. and 3rd segment in *C. columbarius* but not in *C. lectularius*.
b. Environmental effects acting on the ratio through size in *C. columbarius* but not in *C. lectularius*.
c. Differences in the ratio *per se*.

11. The local means of head-width and 3rd antennal segment increase significantly with increase in latitude of the locality for *C. lectularius*.

12. *C. lectularius* and *C. columbarius* produce fertile hybrids from the two reciprocal crosses.

13. *C. columbarius* is regarded as a subspecies of *C. lectularius*.

X. Acknowledgments.

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XI. References.

Butler, E. A., 1923, *A Biology of the British Hemiptera–Heteroptera*, London.

v. Eichler, E., 1937, Über die bei europäischen Vögeln vorkommenden Wanzenarten. *Zool. Anz.* **120** : 267–71.

Fisher, R. A., 1934, *Statistical Methods for Research Workers*, London.

Girault, A. A., 1913, Fragments on North American Insects.—VI. *Ent. News* **24** : 341–2.

Girault, A. A., and Strauss, J. F., 1905, The bedbug *Clinocoris lectularius* (Linnaeus) and the fowlbug *Clinocoris columbarius* (Jenyns) : host relations. *Psyche* **12** : 117–23.

Hase, A., 1938, Zur hygienischen Bedeutung der parasitären Haus- und Vogelwanzen sowie über Wanzenpopulationen und Wanzenkreuzungen. *Z. Parasitenk.* **10** : 1–30.

Horvath, G., 1910, Species nova Europaea Cimicum sanguisugarum. *Ann. Mus. Nat. Hung.* **8** : 361–3.

Jenyns, L., 1839, On three undescribed species of the genus *Cimex*, closely allied to the common bedbug. *Ann. Mag. nat. Hist.* **3** : 241–4.

Kassianoff, L., 1936, Étude morphologique et biologique de la famille des Cimicidés. *Inst. d'Hyg. expt. et de parasit. de l'Université de Lausanne* (Thesis) and *Ann. Parasit. hum. comp.* **15** (1937).

Moens, Wibaut-Isebree, N. L., 1925, Soorten van wantsen in woningen. *Ned. Tijdschr. Geneesk.* **69** (1) : 627–30.

Richards, O. W., 1938, The formation of species. In *Essays on Evolution*, ed. G. R. de Beer, Oxford.

Saunders, E., 1892, *The Hemiptera–Heteroptera of the British Isles.* London (pp. 186–7).

Slack, H. D., 1937, Note on Scottish Hemiptera–Heteroptera. *Scot. Nat.* **1937** : 91.

——, 1938, Chromosome numbers in *Cimex*. *Nature* **142** : 358.

Sumner, F. B., 1932, Genetic, distributional and evolutionary studies of the subspecies of deer mice (*Peromyscus*). *Bibliographia Genetica* **9** : 1–106.

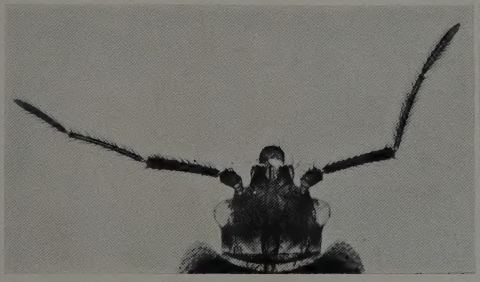
Plate 1.

Fig. 1. Adult females. Right, *lectularius* (Beckenham); left, *columbarius* (Schmeeda).

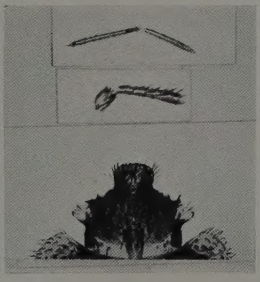
2. Head and antennae of *lectularius*, adult male, (× 22). H.W./3rd = 1·50.

3. Head and antennae of *columbarius*, adult male (Jenyns' original type), (× 22). H.W./3rd = 1·81.

1



2



3

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Cimex lectularius **and** *columbarius.*